Establishment of Cors-Libya

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SUMMARY

Continuously Operating Reference Stations (CORS), especially those integrated as RTK networks, play a very important role in precise geodetic positioning. Coordinates can be determined very quickly and economically without any need for static base stations. Thus, the geodetic surveys, including surveys for geodetic control, planimetry, and cadastral boundaries and so on can be carried out very efficiently.

The main goals of this project are the establishment of CORS stations functioning 24 hours / 7 day and the determination of datum transformation parameters.

CORS-LIBYA consists of a network of multi-functional RTK and DGNSS reference stations providing signals that could be used for geodetic point positioning, land, marine and air navigation. CORS-LIBYA will fulfill all accuracy requirements of geodesy and navigation: centimeter and sub-centimeter levels of accuracy in the post-processing mode, and centimeter, decimeter and meter levels of accuracy in the real-time mode. It will guarantee availability and quality of service continuity. CORS-LIBYA network will consist of 45 reference stations.

In this paper, CORS-LIBYA preparation works will be discussed.

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1 INTRODUCTION

Geographic data plays an extremely crucial role in all kinds of spatial design, planning and applications, hand to hand with efficient usage of resources, in all organized societies. Mapping and engineering works necessitate the usage of up-to-date geographic bases in order to manage and conduct all kinds of spatial works including structural and infrastructural ones.

The rapid technological and scientific developments during recent years have enabled the digital storage of geographic data and the integration of relevant attribute data in computer environment. Geographical / Land Information Systems (GIS / LIS) evolved from the ability to evaluate and manipulate graphic and attribute data within the computer environment. Nowadays, GIS / LIS became inseparable part of our life. Geo-information has a lot of uses. For instance, *administration of state, forest, environment, and city planning, determination of land usage and agricultural policy, engineering structuring, evaluation of infrastructure and natural resources, multi-purpose cadastre, e-government, e-municipality, e-commerce, and all other activities that depend on spatial information,* are just few examples.

It is a must to determine the position (i.e. coordinates) using reliable methods, as it is the base in cadastre, mapping and GIS / LIS. Otherwise, problems of inconsistency and poor integration would be faced. The technology of Global Positioning System (GPS) has opened a new era regarding the determination of positions. Despite the fact that GPS technology has entered developing countries in 1990's, public and private establishments are still using uneconomical old-fashion methods and techniques. That is where CORS-LIBYA Project comes into the picture; targeting the substitution of old inefficient systems with a single, fast, efficient, economical, reliable and modern system that can serve in the northern region of Libya, where great majority of Libyan population is located.

Libya has recently started national mapping requiring significant geodetic positioning. It is required to carry out such and other geodetic positioning and surveys rapidly, economically and precisely. All these features can be met by using the most recent Global Navigation Satellite System (GNSS) techniques known as network based Real Time Kinematic (RTK) Continuously Operating Reference Stations (CORS) positioning. Therefore, as part of the national mapping project, SDL decided to establish *"Network Based Libyan RTK CORS"*, hereafter this system will be called ***CORS-LIBYA***.

CORS-LIBYA System will provide cm-level positioning in real time 24 hours daily throughout the coastal region of Libya (Figure - 1). It will consist of about 45 GNSS CORS with one control centers. Thus system will not only serve national mapping project surveys but it will also serve all types of geodetic positioning, terrestrial surveys and mapping, engineering surveys, vehicle tracking, precise navigation, tectonic studies, etc. With the operation of this system, Libya will have tremendous saving economically and time wise.

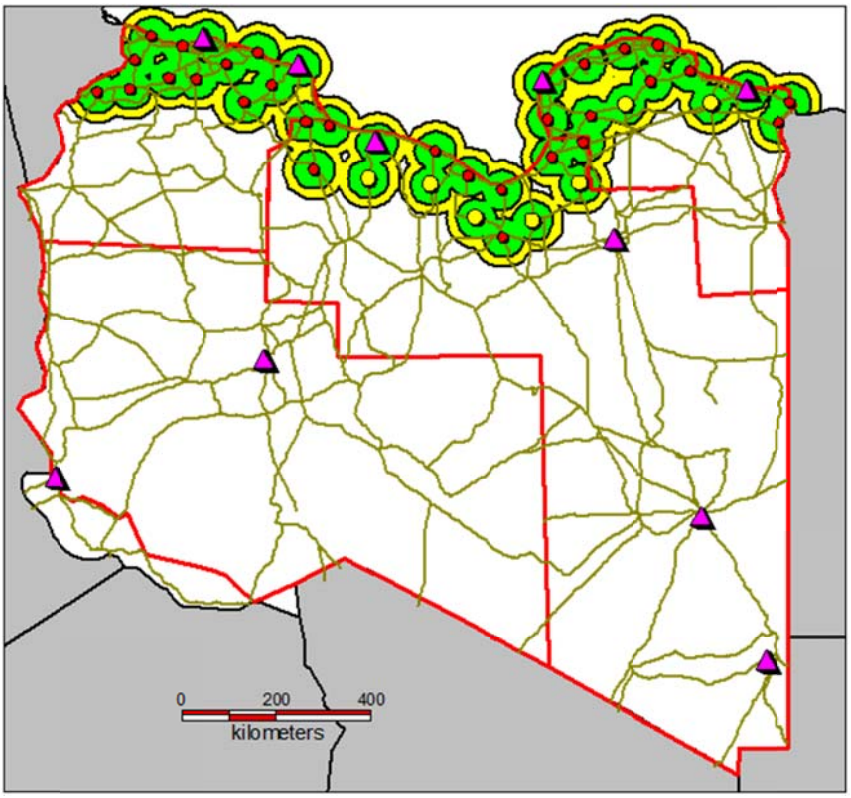

Figure - 1. CORS-LIBYA stations and coverage at 40 and 60 km interstation distances

2 OBJECTIVES OF THE PROJECT

2.1 General Objectives

Continuously Operating Reference Stations (CORS), especially those integrated as RTK networks, play a very important role in precise geodetic positioning. Coordinates can be determined very quickly and economically without any need for static base stations. Thus, the geodetic surveys, including surveys for geodetic control, planimetry, and cadastral boundaries and so on can be carried out very efficiently.

The main goals of this project are the establishment of CORS stations functioning 24 hours/day as presented below:

Goal-1: Providing continuous real-time cm-level precise geodetic positioning throughout Northern Libya (i.e. 24 hours/day, 7 days/week) for collecting geographic data, including data for national mapping, military, development, engineering surveys and cadastre, by much faster, more economical and reliable means, all in the same format and standards. This system will provide fast response to SDL in the production of maps and associated data such as o Establishment of Geodetic Control Points (leveling, polygon...etc.);

- Terrestrial mapping, land surveying and cadastral measurements;
- Other terrestrial measurements for GIS/LIS applications.

Goal-2: Providing dm- and m-level positioning for navigation and vehicle tracking in air, land and sea.

Goal-3: Modeling the atmosphere (troposphere and ionosphere) over northern Libya and contributing to atmospheric studies and weather predictions, as well as studies on signals and communication.

Goal-4: Providing mm-level accuracy for tracking plate tectonics, subsidence, measuring deformations and contributing to early warning systems.

In summary, the aim of this project is to provide fast, accurate, and reliable means for collecting all kinds of geographic data, thus, speeding up the activities of national mapping, cadastre, assuring organized urbanization, constituting the spatial infrastructure for relevant works of e-government, and monitoring plate tectonics. When the project concludes, we will have the ability to acquire coordinate information with a cm-accuracy in a matter of seconds, from any place and at any time in northern Libya, using a methodology regarded as highly economical when compared to classical static surveys, which may require 1 to 2-hour observation times.

CORS-LIBYA Project will have very important contributions in the fields of civil and scientific applications. Some of these contributions are listed below:

Civil Applications
- Geodetic measurements;,
- Mapping and GIS measurement;
- Planning and environment;
- Monitoring of engineering structures;
- Precise navigation and vehicle tracking;
- Infrastructure measurements and project applications ;
- E-government, e-municipality, e-commerce applications; and
- All other geo-information projects.

Scientific Applications
- Earthquake engineering;
- Seismology;
- Monitoring and analysis of disturbances in ionosphere and troposphere;
- Meteorology; and
- Smart transportation.

2.2 Specific Objectives

Specific objective of CORS-LIBYA is to take advantage of the system for

- Establishment of Ground Control Points (GCPs)
- Field completion using RTK positioning
- Serving engineering, cadastral and other surveys in the region

Thus, all type of positioning users shall see the great advantages of

- RTK and rapid positioning
- Results in the same format and standard eliminating the necessity for data conversion and integration

3 SCOPE OF THE WORK

3.1 Scope

This is very high-tech project requiring expertise in geodesy, GNSS techniques, cadastral registration, telecommunications, and management of IT projects.

With CORS-LIBYA System it is targeted to enable all users all over Northern Libya to determine positions through RTK. Within CORS-LIBYA Network the coverage of RTK is anticipated to be at most 50 km from the nearest station. Thus, the spacing between CORS stations is thought to be 50-100 km for all Northern Libya as illustrated in Figure - 1.

Within the scope of this project: GNSS reference stations will be established to serve the users in northern Libya, operating with Real-Time Kinematic (RTK) functionality, based on the network concept. Thus;

- Real-time usage of the system will be possible;
- All users will be able to get service from the center(s) to be established;
- Basis of all geo-information technologies will be constituted; and

In brief, CORS-LIBYA Project will remove the necessity of ground monument construction in the field of mapping in Northern Libya to great extent; will provide the users with high-tech's convenience and products. Each reference station within CORS-LIBYA system will hold the characteristics of CORS Network and will provide the capability of cm-level real-time positioning within its own "jurisdiction" area. The system, at the same time, will be web-based and will assist the users with data post-processing. The CORS-LIBYA system will be integrated into Libya's National Geodetic Network.

As far as methodologies are concerned, the fundamental two activities are as follows:

- CORS-LIBYA System Design (Station Location, Monumentation, Site Preparation,
- Software/Hardware.etc.;
- CORS-LIBYA System Installation and Operation;

3.2 Tasks

The scope of work consists of five major tasks presented below;

1. CORS Design and Monumentation
2. CORS Site Preparation
3. Selections of CORS GNSS Receivers and Antenna
4. Establishment of CORS Control Center (CC) and Selection of CC Software
5. Establishment of CORS Infrastructure and Communication

4 METHODOLOGY

4.1 System Design

The establishment of a total of 50 CORS is estimated to cover the northern region of Libya. Figure -1 show CORS coverage using 45 tentatively selected stations and 60-100 km interstation distances.

The basic requirements of the reference stations as outlined in the RFP are as follows:

1. Needs to be able to stream raw GPS data back to the Control Center (CC) 24/7,
2. Needs to be able to continue operation in the event of a prolonged AC mains outage of up to 48 hours,
3. May be located out of doors,
4. Requires the use of ADSL as the primary communications medium and EDGE or GPRS for backup.

Before any configuration of equipment can begin, an assessment of the worst case environmental operating conditions will be done to establish the temperature ranges under which the equipment will be expected to operate. After this is done, appropriate third party devices will be integrated into a reliable operational reference station configuration.

In view of the requirements above, CORS-LIBYA system design will include:

- Determination of station locations;
- Determination of GNSS receivers of CORS Network;
- Determination of software packages of CORS Network;
- Determination of CORS control center; and
- Determination of the requirements of Communication and power (electricity, phone, internet...etc).

With CORS-LIBYA, it is targeted to enable all users all over Northern Libya to determine positions through RTK. Within CORS-LIBYA Network the coverage of RTK is anticipated to be at most 40 km from the nearest station. Thus, the spacing between CORS stations is thought to be 60-100 km. The most extensive usage of CORS stations will be in urban areas. Furthermore, when keeping in mind the other necessities of CORS stations, like energy, communication...etc., then the selection of station locations will be dependent on the following criteria:

- Shall be in urban centers;
- Shall be on solid foundation (away from landslides); and
- Shall have electricity and communication facilities, including Internet access.

The main characteristics to be sought in the GPS receivers that will be deployed at CORS stations are:

- Must be dual-frequency GNSS receiver with choke-ring antenna or equivalent;
- Must be compatible with GPS, GLONASS and "the coming soon" GALILEO
- Must be web-based; and
- Must be capable of all kinds of communication (e.g. radio, GSM / GPRS/ Edge, Thuraya, NTRIP, Internet...etc).

A pre-requisite of the CORS software would be its ability to correct for ionospheric, tropospheric, multi-path and orbit effects and facilitate the usage of these corrections for RTK positioning up to 50 km away from CORS network stations. The selected software will be required to enable the implementation of three famous techniques being used worldwide:

- MAC (Master Auxiliary Concept)
- FKP (Flachen Korrectur Parameter) – for linear area correction parameters,
- VRS (Virtual Reference Stations).

The administration of CORS-LIBYA system will be conducted from one center. The entire data of CORS-LIBYA stations will be automatically forwarded to this center, where all CORS Network calculations will be conducted and corrections passed to users.

For the sake of communications, RTCM 3.0 or higher and more advanced protocols will be used, thus radio, GSM, GPRS / EDGE, NTRIP (Network Transport of RTCM through Internet Protocol) communications will be assured.

4.2 Monumentation

It is participated that most reference stations will be established on the roofs of government buildings (such as municipalities, universities, hospitals, etc.). Some public lands with open sky and communication infrastructure will also be considered.

All reference stations will be monumented by using either

- solid steel structure on roofs,
- concrete pillar on soil – ground.

4.3 Site Preparation

Upon the conclusion of CORS station constructions, receivers and accessories will be setup and installed. The accessories consist of external batteries & chargers, fans, switches, lightning and surge arrestors, Router.

The CORS sites require the connection of electricity and telephone / ADSL line. They will be installed properly and connected to the accessories in the cabinet.

4.4 CORS-LIBYA Reference Stations

Each of the CORS set will consist of one receiver, one GNSS antenna and other accessories specified in this RFP. CORS-LIBYA reference stations will provide all type of GNSS today's and future signals according to the GNSS signals modernization program and GLONASS.

GNSS receivers at reference stations run continuously. The raw measurement data are usually logged internally in the receivers in files of the required length. CC software running on the server controls the receivers and downloads the data files automatically at regular intervals. Receivers can also stream raw data continuously to the server instead of logging data or even stream raw data at the same time as they are logging data, provided that it safeguards the loss of data.

In the CORS-LIBYA project, it is intended that, using permanently open communication links, raw data will be streamed continuously from the receivers to the CC. Software running on the CC will utilize data including the computation of the required RTK/DGNSS data continuously in standard RTCM V 3.x format.

In order to be able to use the data, RTK rover receivers have to be RTCM V3.x compatible. They have to understand the RTCM V3.x format and they have to be able to apply the network correction parameters. All RTK rovers operating within the network can receive correction parameters. Nevertheless, the system must allow interoperability with other manufacturers' receivers.

In conformance with the RFP, the main features of CORS systems are:

- Must be dual-frequency GPS receiver with choke-ring antenna or equivalent;
- Must be compatible with GPS, GLONASS and "the coming soon" GALILEO
- Must be web-based; and
- Must be capable of all kinds of communication (e.g. radio, GSM / GPRS/ Edge, Thuraya, NTRIP, Internet...etc)
- Must have a Control Center with network-based software package

4.4.1 Reference Stations

The reference station shall be as simple as possible so as to minimize box count and thus maximizing reliability. The charger maintains the batteries as a float of 26.7Vdc which

powers the site. When the AC mains go off, the batteries will immediately drop to their normal full charge voltage of 2 x 12.84V or ~25.7Vdc. The GPSNet alarming will be set to generate an email alarm if the power supply to the receiver drops below 26Vdc and hence, will inform the sys-administrators that AC mains have failed at a site.

Battery system is designed to provide 48 hours of standby power for the reference station.

Communications will be over ADSL primary and ADGE secondary. The router will establish its ADSL connection to the internet and then immediately open up a VPN tunnel to the CC. Once the VPN tunnel is up, a GRE tunnel will be created inside this VPN tunnel. This technique has the following advantages:

- We do not care what the IP address of the reference station router is which means we could be using the EDGE wireless interface or the ADSL, makes no difference,
- It is secure, outsides cannot tamper, change or view the data,
- GRE tunnels support multi-cast and routing updates whereas IPSec VPN tunnels on their own do not.

The Router at CC will NOT initiate VPN tunnels to the reference station but will only listen, waiting for the reference stations to contact it to initiate the VPN tunnels. This is so as the reference station could have:

1. Dynamic IP addresses on ADSL and EDGE,
2. Static IP on ADSL and dynamic on Edge,
3. One static IP on ADSL and a different static IP on EDGE.

4.4.2 Reference Receiver System Accuracy

1. The receiver shall provide full-wavelength precise carrier phase on L1 and L2 in the presence of A/S;
2. The receiver must have precision better than 15 mm rms value both on L1 and L2 based on 24 hour observation;
3. When the correct number of satellites is visible, there are minimal or no obstructions, there is minimal multipath or ionospheric activity and the reference station position is correct, the system must yield :

Static / Fast Static mode:		
Horizontal:	5 mm +	1.0 ppm RMS
Vertical:	10 mm +	1.0 ppm RMS
RTK mode:		
Horizontal:	10 mm +	1.0 ppm RMS
Vertical:	20mm +	1.0 ppm RMS

4.5 Network Software Control Center (CC)

- There will be only one CORS-LIBYA CC to be established at SDL. CC is the core of the entire project, amongst others ,
- providing communication with CORS and rover receivers;
- getting data from CORS receivers;
- modeling errors;
- calculating FKP, VRS, PRS, MAC and other corrections;
- data screening;
- creation of virtual data; and
- RTCM output.

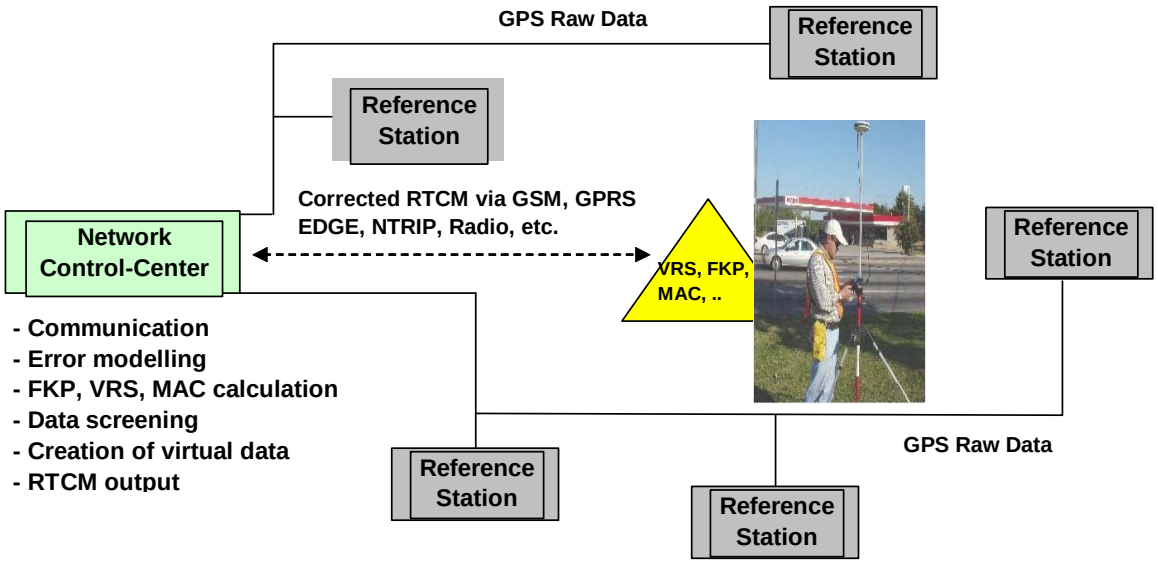

Figure 2. CORS-LIBYA Control Center

The CORS-LIBYA Project will utilize both one way and two-way communications. One way communication link receives all necessary correction/reference data and determines absolute RTK position anytime/anywhere with geodetic accuracy, whereas two-way communication link receives rovers' data and communicates all necessary correction/reference data and determine absolute RTK position anytime/anywhere with geodetic accuracy.

In the CORS-LIBYA project, the raw data shall be streamed continuously from the receivers to the server. Therefore, the communication links between the receivers and the server shall be permanently open. As a rule of thumb, the estimation for the required bandwidth at one Cc: 50 stations * 10 kbit = 0.5 Mbit for existing signals from GPS and GLONASS. Accordingly, CC might need at least a 1 Mbit DSL connection. This task will be taken care of by the clients.

Due to aforementioned reasons, the trend today is to try to make use of the Internet to achieve permanently open links for streamed data between the receivers and the server. As stated above, running costs with the Internet are significantly lower than with telephone connections. Therefore, in this particular project, CORS-LIBYA GNSS data flow between CC and CORS

sites will be provided via ADSL using Telecom fixed line, or GPRS / EDGE provided by GSM or Thuraya.

Mobile phone modems (GSM, CDMA, TDMA, GPRS, EDGE, Thuraya Satellite…etc) can be used if standard telephones are not available at the reference station sites. The phones have to be powered and permanently switched on. However, running costs (call charges) will often be higher than with standard landline.

There is a rapidly growing interest today in using IP-based methods for communication between the CORS receivers and the CC software, and also for distribution of RTK and DGNSS data. IP-based communication can be LAN, WAN, WLAN, Internet, Intranet, and Radio IP…etc. So, the servers are usually connected to the receivers by telephone, LAN, WAN or Internet.

The main attraction of using the Internet for communication between the server and the receivers is that it is usually possible to reduce running costs. Since, in this project, the raw data will be streamed continuously from the receivers to the server at the CC, the running costs with the Internet will be much lower than with telephone connections.

Communications between the CC – CORS receivers and CC – rovers can be via telephone (i.e. fixed line, GSM, satellite systems), Internet, or Radio. However, the most useful and economic communication is Network Transport of RTCM via Internet protocol known as NTRIP. Therefore, a brief description of NTRIP is provided here.

In order to access the Internet, the receiver at a CORS site will require a modem, a Com Server or Ethernet port, and a static IP address. The modem could be a telephone, cable, or broadband ADSL modem. There will be a main and a backup communication line for each CORS station. Main communication can be ADSL and the backup as GPRS/EDGE or vice versa. For this purpose a router should be used, which is capable of both communications with automated switching between them in case of failure.

The server will require a suitable modem and one IP port for each reference station from which data will be streamed. Thus, 50 IP ports are needed if data is to be streamed from 50 stations. The modem could be a telephone, cable, or broadband ADSL modem. Since the server at the CC will receive continuously streamed raw data simultaneously from CORS stations, the best would be a broadband ADSL or cable modem with a suitably large bandwidth.

So, RTK/DGNSS RTCM V3.0/3.1 data can be distributed to rovers using the following means:

- Internet (GPRS, UMTS)
  - bidirectional or uni-directional;
  - NTRIP;
- Fixed and mobile phones (GSM, Thuraya…etc);
- Broadcast media;
  - VHF, TV, Radio, Satellite communication.

If radios are used, the RTCM V3.x network data stream will probably have to be redistributed via repeater stations or transmission stations in order to ensure full coverage over the network area.

If phones are used, all rovers should be able to dial a single number for the RTCM V3.x network data stream. A suitable router will be needed to ensure simultaneous multiple user access.

If the Internet is used, all rovers should be able to access the same IP address for the RTCM V3.x network data stream. Multiplexing software running on the server will allow simultaneous multiple user access.

Providing DGNSS and Network RTK correction data via Internet is the standard provisioning procedure of CORS-LIBYA for real time applications. It makes possible in a short-time establishing of these sub-services with moderate costs and based on available communication infrastructures. In order to access the Internet and obtain the required data, RTK and GIS rover receivers have to be equipped with Internet capable devices such as GPRS or CDMA phone modems.

CORS network software and CC shall also give the results on followings;

- Computations of Corrections and Distribution of RTK / DGNSS Data
- Filing data and FTP Distribution of RINEX data
- Supervising the system's operation
- Data analysis
- Operation reports
- Handling problems
- Post-processing services

5 CONCLUSION

Libya has recently started national mapping requiring significant geodetic positioning. It is required to carry out such and other geodetic positioning and surveys rapidly, economically and precisely. CORS-LIBYA System will provide cm-level positioning in real time 24 hours daily throughout the coastal region of Libya. Project is in tendering process and will be completed in six months after contract signing.

BIOGRAPHICAL NOTES AND CONTACT INFORMATION

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He was born in Libya at 1951. He had his engineering diploma at 1971 and BSc degree from Oregon Institute of Technology (OIT)-USA at 1983. He works at SDL as Head of IT Department and executes the `Libyan National Mapping Project`.

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He was born in Libya at 1963. He had Civil Engineering BSc degree at 1986 and MSc Degree in Remote Sensing at 1994. He finished his PhD at Newcastle University at 2004. He had worked as lecturer at Al Fatah University between 1994-2006. He is a member of `Space in Civilian Purposes Commission` for North African Countries Union and `Regional Center of Remote Sensing` Commission. He is the Director General of Surveying Department of Libya since 2006. He is the chair of the executive board of `Libyan National Mapping Project`.

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